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Collembola assemblages of fen meadows in the nature reserve Stroomdallandschap Drentsche Aa (Netherlands) – the preliminary study.

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Kurzfassung: Die Untersuchungen wurden auf Niedermoorwiesen im Naturschutzgebiet „Stroomdallandschap Drentsche Aa“ in den Niederlanden an fünf verschiedenen Stellen durchgeführt, an denen die Düngung eingestellt wurde (1, 5, 10, 25 und 32 Jahre). Es werden die vorläufigen Ergebnisse der Untersuchung der Springschwanz-Gesellschaften in diesen ausgemagerten Niedermoorwiesen dargestellt. Bei allen untersuchten Wiesen ist die Artendiversität, gemessen nach dem Shannon-Wiener-Index, sehr gering. Die Abundanzen und der Artenreichtum zeigen die Tendenz, während der ersten 25 Jahren nach Einstellen der Düngung anzusteigen, während sie nach 32 Jahren abfallen.

Summary: The studies were carried out in fen meadows in the nature reserve Stroomdallandschap Drentsche Aa (Netherlands) at 5 sites differing in the period after cessation of fertilisation (1, 5, 10, 25 and 32 years). The preliminary analysis of changes in the Collembola assemblages in restored fen-meadows is presented. In all studied sites the species diversity measured by Shannon-Wiener index was very low. The abundance and species richness show the tendency to incerase with time during the first 25 years of restoration and to decline in meadows that had not been fertilised for 32 years.

Key words: biodiversity, restoration, wetlands, Collembola.

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Introduction

Fen meadows are an important type of semi-natural grassland. They develop in areas with high ground water level in alluvial soils in post-glacial valleys within the range of glaciations and in former peat bogs. A common practise in meadow management is to apply large amounts of mineral fertiliser which are known to affect soil animals and, therefore, the reclamation processes must involve restoring properly functioning communities of soil fauna. The essential role of soil fauna in reclamation process has been underlined by Curry & Boyle (1995) and soil fauna restoration processes have been studied in colliery spoil heaps (Dunger 1989; Stary 2001), cutover peatlands (Curry & Boyle 1995), polder soils (Hoogerkamp et al. 1983), afforested farmland (Szujecki 1983). Many of these studies have focused on the process of colonisation and amelioration of the soil macrofauna (*Lumbricdae*) communities and soil conditions or on the effect of long-term changes in grassland communities of heterothrophic organisms on drained fens (Kajak et al. 1985), but did not deal with the diversity and community structure of soil fauna during the restoration of the meso- and oligotrophic conditions at the sites. Studies on the soil animal community in fen meadows differing in time after the cessation of the fertilisation are very rare and have been presented only for measurement of diversity of soil macro-invertebrates (Hemerik & Brussaard 2002).

The main goal of the study was to highlight whether different durations of restoration management by haymaking after cessation of fertilisation are reflected in the organisation of the collembolan assemblages.

Material and methods

Study area

The Drentsche Aa brook valley reserve is the best-preserved valley system in the northern part of the Netherlands. Since 1965, when the reserve was established, the process of restoring former species-rich plant communities has been ongoing. Restoration management by haymaking of fen meadows started after a period of agricultural intensification on sites where fertiliser applications were ceased a shorter or longer period of time ago (Bakker & Grootjans 1991; Bakker & Olff 1992; Bakker & Olff 1995; Bakker et al. 1995).

Sampling

The material collected only during spring season 2000 at five localities, which differ in time since the last fertilisation (1 year, 5 years, 10 years, 25 and 32 years) have been taken into consideration. 36 pooled samples have been analysed, 8 subsamples in each meadow not fertilised for 5, 10, 25, 30 years, and 4 subsamples at a meadoe not fertilised for one year. Each sample was taken to 16-cm depth using a modified steel corer after Bieri et al. (1978) with a diameter of 5.5 cm and divided into four levels. The samples were extracted in MacFadyen high gradient type apparatus.

Environmental properties

Humidity, pH and organic matter content were measured at the studied sites. Soil pH was measured in 0.01 M CaCl2 using a pH meter. Soil moisture was determined by weighing the samples before and after drying at 105° C. Organic matter content was measured as the amount lost (%) when samples were ignited at 600° C in a controlled muffle furnace for 10 hours. The measurement of humidity, pH and organic matter content are presented as an average (Table 1).

Biocenological analysis

The collembolan assemblages were evaluated using the following indices: abundance, indices of diversity (Shannon-Wiener, Pielou evenness index). The similarity of samples was measured at the species level using Jaccard coefficient; the basis for grouping was the complete link. Pearson correlation was used to analyse the relationship between environmental variables and abundance of Collembolan for all sample.

Results

38 species were found during spring in the restored meadows (Table 2). The highest species richness and abundance was observed in meadows not fertilised for 25 years (Fig. 2). After 25 years the basic parameters of animal communities, abundance and species richness, tended to decline. The analysis of the relationship between environmental variables and abundance of Collembola

Table 1. Mean value and standard deviation of soil parameters in the studied fen meadows.

Years since last fertilisation	1	5	10	25	32
Humidity (%)	64,22±13,38	54,91±12,88	59,88±12,69	72,27±22,54	80,38±21,71
pH	5,11±0,30	4,43±0,09	4,91±0,18	4,67±0,18	3,51±0,23
organic matter content (%)	8,80±1,90	6,49±1,93	7,42±3,06	13,02±7,87	35,68±25,31

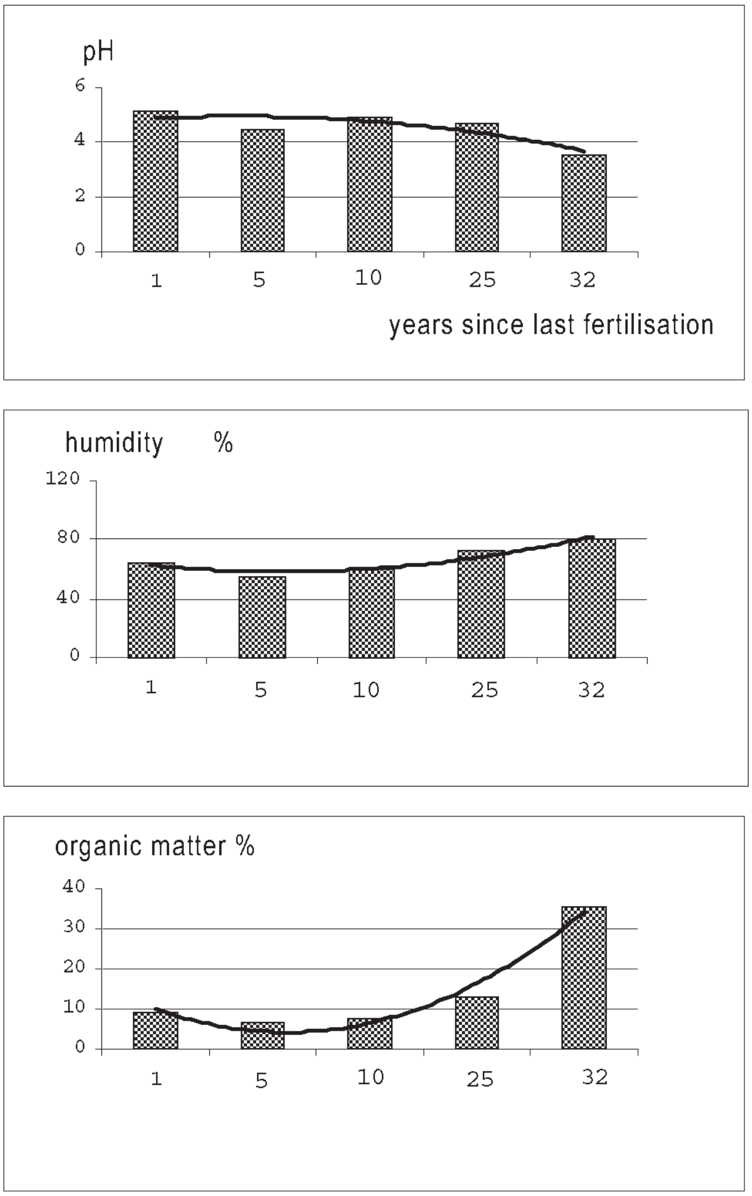

Fig. 1. Trends in changes of environmental variables in fen meadows studied

Table 2. Mean abundance (ind./m²) of Collembola in the studied plots.

Years since last fertilisation	1	5	10	25	32
Brachystomella parvula (Schäffer, 1896)	673.05	0	336.56	48.08	384.64
Anurida uniformis Gisin. 1953	0	0	240.40	0	0
Microanurida pygmaea Börner. 1901	96.15	0	1105.84	0	48.08
Friesea truncata Cassagnau. 1958	96.15	673.12	961.60	5481.12	240.40
Xenyllodes armatus Axelson. 1903	0	192.32	0	0	0
Ceratophysella denticulata (Bagnall. 1941)	0	0	0	48.08	0
Protaphorura armata (Tullberg. 1869)	0	48.08	0	96.16	0
Protaphorura cancellata (Gisin. 1956)	0	0	48.08	0	0
Protaphorura pannonica (Haybach. 1960)	0	0	0	48.08	0
Protaphorura subuliginata (Gisin. 1956)	0	0	0	865.44	0
Protaphorura tricampata (Gisin. 1956)	0	48.08	0	432.72	0
Protaphorura sp. juv	0	0	0	48.08	0
Stenaphorurella quadrispina (Börner. 1901)	0	48.08	0	48.08	0
Paratullbergia macdougalli Bagnall. 1936	0	0	528.88	48.08	48.08
Mesaphorura macrochaeta Rusek. 1976	0	0	1923.20	48.08	144.24
Mesaphorura krausbaueri Börner. 1901	1346.10	96.16	721.20	1923.20	721.20
Mesaphorura pongei Rusek. 1982	0	0	48.08	0	673.12
Mesaphorura sp.	96.15	48.08	48.08	96.16	48.08
Folsomia quadrioculata s. l. (Tullberg. 1871)	0	0	0	0	48.08
Folsomia candida (Willem. 1902)	192.30	288.48	0	144.24	96.16
Cryptopygus exilis (Gisin. 1960)	0	48.08	0	96.16	0
Cryptopygus sp.	0	0	0	48.08	0
Proisotoma coeca da Gama. 1961	96.15	0	0	48.08	0
Proisotoma dottrensi Gisin. 1952	192.30	0	0	96.16	0
Proisotoma minima (Absolon. 1901)	96.15	48.08	1346.24	865.44	192.32
Isotomodes armatus Naglitsch. 1962	0	0	192.32	0	48.08
Parisotoma notabilis s. l. Schäffer. 1986		6971.60	2452.08	3173.28	3029.04
Isotomiella minor (Schäffer. 1986)	96.15	0	96.16	9952.56	4182.96
Isotoma anglicana Lubbock. 1862	96.15	144.24	0	96.16	0
Isotoma viridis Bourlet. 1839	192.3	0	0	0	0
Desoria nivalis Carl. 1910	0	48.08	0	0	0
Desoria sp.	0	480.80	0	0	0
Isotomurus palustris s.l. (Müller. 1776)	1153.80	1346.24	48.08	192.32	48.08
Isotomidae sp. juv	0	96.16	3798.32	0	48.08
Isotomidae undet.	0	48.08	144.24	144.24	48.08
Lepidocyrtus lignorum (Fabricius. 1793)	0	96.16	96.16	96.16	48.08
Lepidocyrtus lanuginosus (Gmelin. 1788)	0	0	0	48.08	0
Entomobryidae sp.juv.	0	0	0	96.16	0
Arrhopalites caecus (Tullberg. 1871)	0	0	48.08	96.16	0
Megalothorax minimus Willem. 1900	0	48.08	48.08	0	0
Sminthurides pumilis (Krausbauer. 1898)	96.15	625.04	0	817.36	336.56
Sminthurus aureus (Lubbock. 1867)	0	0	0	48.08	0
Sminthuridae sp.juv	2115.30	2644.40	5096.48	13702.80	6875.44
Sminthuridae undet.	0	48.08	96.16	0	0
Abundance total	6634.35	14135.52	19424.32	38992.88	17308.80
Number of species	14	18	18	27	17

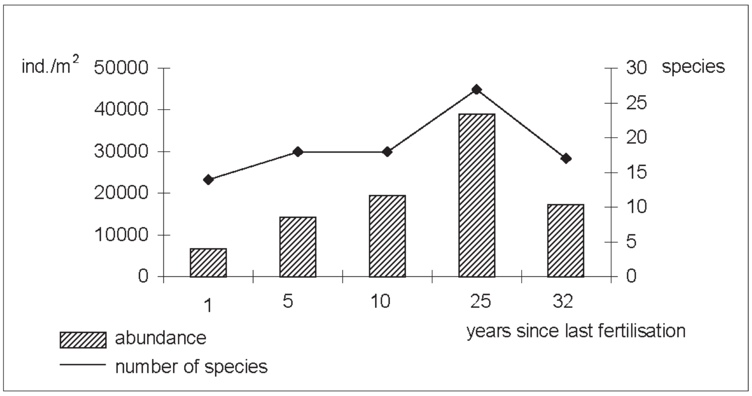

Fig. 2. Changes in basic parameters of the Collembola assemblages in restored fen meadows

for pooled data did not show any significant correlation (Pearson coefficient value between abundance of Collembola and humidity is 0.36, pH is – 0.07, organic matter content – 0.07).

Species diversity of Collembola measured using the Shannon-Wiener index was very low at all sites and ranged from 0.764 in meadows that were not fertilised for 32 years to 0.978 in meadows not fertilised for 10 years (Table 3). The degree to which potential species diversity is achieved, expressed as Pielou index of evenness, shows that the highest value of evenness of collembolan assemblages is reached in the meadows not fertilised for one and 10 years (0.747; 0.729 respectively).

The cluster analysis of faunistic data shows that Collembola from meadows not fertilised for 10 and 32 years are clustered together. The separate and unlike Collembola species occurr in meadows not fertilised for one year (Fig. 3).

Discussion

As for vegetation, the process of restoration of fen meadows by stopping fertiliser inputs and exporting organic matter and nutrients through hay making led to a rather rapid increase in species diversity and the re-establishment of a number of species typical of wet and nutrient-poor meadows (Berendse et al. 1992). The applied type of restoration management, except the changes in vegetation, provoked changes in abiotic factors (Bakker, Olff 1995). In fen meadows with the longest history of restoration (32 years) the acidity of soil is lowering, while the humidity and organic matter content increase (Table 1, Fig. 1). For the soil animal communities factors such as organic matter accumulation, pH, moisture and microclimatic stability may be more important than vegetation complexity and diversity (Parr 1978; Usher et al.1982; Dunger 1989). In many natural and disturbed areas Collembola belong to the early colonisers (Dunger 1989). The collembolan colonisation and establishment in restored grasslands ecosystems can occur more rapidly when site conditions are favourable and when the sources of colonisers are available.

Table 3. Diversity indices of Collembola assemblages in restored fen meadow

Years since last fertilisation	1 year	5 years	10 years	25 years	32 years
H'	0.879	0.766	0.978	0.834	0.764
H_{max}	1.176	1.342	1.342	1.491	1.301
E	0.747	0.571	0.729	0.560	0.588

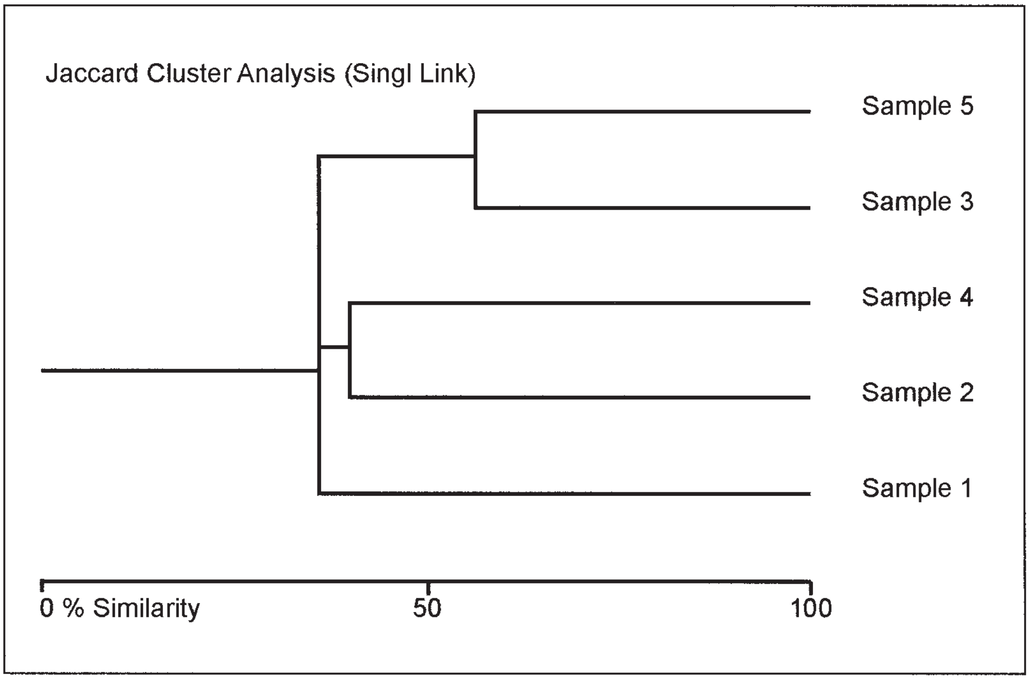

Fig. 3. Jaccard cluster analysis (single link) of Collembola in fen meadows.

The first observation of restoring of soil Collembola in fen meadows showed that this process is very slow as it was observed for soil macro-fauna re-establishment on industrially mined cutover peat (Curry & Boyle 1995).

The restoration management of fen meadow system by haymaking without fertiliser application influenced the basic parameters of soil Collembola assemblages (species richness and abundance) but did not markedly change the level of species diversity (Fig. 2, Table 3). The lowest abundance and species richness is observed in the meadow where fertiliser application was stopped one year ago and they show the tendency to increase with time during the first 25 years of restoration (Fig. 2). In the following years, 32 years since the last fertilisation, the abundance and species richness of collembolan assemblages get lower again. The abundance of Collembola did not show any significant correlation with environmental variables (pH, humidity, organic matter content).

Comparing the restoration management resulted in pattern of soil macrofauna, for most taxonomic groups, the lowest catches of individuals have been observed for the site with the longest history of impoverishment (29 years), in contrast to sites with the shortest history of restoration management (Hemerik & Brussaard 2002).

The applied type of restoration management provokes the changes in species composition of Collembola (Sterzyńska, Ehrnsberger in press). The acidiphilous and hygrophilous species are recorded in sites where soil moisture is increasing and acidity is lowering. The history of the area is reflected in the presence of numerous compost or preferred disturbed habitat species. This type of observation is confirmed by the cluster analysis of the fauna of the sites (Fig. 3). Observed changes in the species composition are not reflected in the measurement of species diversity. The species diversity indices of soil Collembolan communities are very low and did not show any differences in the studied fen-meadows (Table 3). It could be hypothesised that approximately 30 years of restoration of fen-meadows by cessation of fertiliser application is not enough to restore the advance and diverse soil Collembola assemblages. Rusek's studies on succession of Collembola on a pingo in the Mackenzie River Delta show that collembolan assemblages were better differentiated than the number of vegetation types across the studied transect (Rusek 1994). In that sense, the preliminary relevance of Collembola assemblages on formerly heavily fertilised fen-meadows probably did not indicate very clear changes.

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